Remarks

The Examiner is thanked for allowing claims 1 - 5 and 7 - 10 and moreover identifying additional allowable subject matter in the claims identified in part 7 of the Official Action.

However, the Examiner does reject a number of the claims pending in this application as being unpatentable over the prior art. The applicant believes that these rejections are not appropriate, and therefore the Examiner's grounds for rejection are traversed as indicated below.

The Rejection of Claim 11 based on Willebrand

The Examiner rejects claim 11 under 35 U.S.C. 102(e) as allegedly being fully anticipated by U.S. Patent No. 6,239,888 to Willebrand. As indicated above, this grounds for rejection is respectfully traversed.

In rejecting claim 11, the Examiner uses the term "propagation distortions" as if it appears in Willebrand. See page 3, line 6 of the Official Action. However, so far as the Applicant can tell, the term never appears in Willebrand nor is it believed that Willebrand concerns itself in any way with propagation distortions.

As such, Willebrand does not seem to deal with the correction of propagation distortions. Rather Willebrand is concerned with several detrimental effects: (1) the "bending," or "refraction" caused by "atmospheric conditions" (See Willebrand, column 14, 2nd whole paragraph), (2) "minor movements of the buildings," resulting in a lateral shift of the beam relative to where the optical systems are placed, and (3) optical attenuation due to the atmosphere. These "effects" are not "propagation distortions". Rather, they either merely shift the apparent position of a pristine beam or merely attenuate the beam. Propagation distortions due to the atmosphere, on the other hand, are typically caused by random atmospheric fluctuations due to thermal and pressure gradients and multiple scattering effects, all of which result in a transmitted beam's image or spot becoming spatially unrecognizable at the receiver location. Thus, these deleterious propagation effects result in wavefront distortions, not merely the bending, shifting or attenuation of the beam. In general, a transmitted optical spot will, upon propagation through the atmosphere, result in a highly distorted beam, which, in general, can be in the form of many randomly distributed optical "blotches" (each of which may no longer even resemble a spot) at

the receiver.

Such general propagation distortions and the resultant wavefront distortions are not addressed, discussed or anticipated by Willebrand. Willebrand "corrects" very limited propagation effects (not distortions) by merely "shifting" the location of the receiver to, in essence, collect the "bent" optical beam. In addition, Willebrand "compensates" for a lower optical power at the receiver by merely increasing the transmitted power (this tantamount to "correcting" a leak in a garden hose by turning up the faucet). Willebrand has no means by which to address a generally distorted beam.

A song, which is familiar to many children in the United States, is "Twinkle Twinkle Little Star". Stars twinkle because of complex distortions caused in the earth's atmosphere. If the earth's atmosphere only induced the sort of propagation effects discussed by Willebrand, each star would look like a round disc and the song "Twinkle Twinkle Little Star" would have never been written. In the Willebrand view of the atmosphere, the stars might shift their apparent position somewhat due to the atmospheric bending and their brightness might be attenuated somewhat, but they do not twinkle in a general sense because there would be no propagation distortion.

If an arriving beam is in the form of a random spatial pattern of "blotches" due to propagation distortions, Willebrand's system has no method by which to process all these spots. It can be shown that, given Willebrand's system configuration, each "optical blotch" will be of a lateral dimension approximately equal to the receiver aperture. Thus, if the spatial pattern consists of a 10,000 such spots, Willebrand's system will only be able to detect a single blotch, or 1/10,000 of the optical power at best (assuming that his lateral positioner can collect its theoretical maximum power in a single spot). Willebrand's system will measure the received power and "correct" this huge reduction in detected power ("attenuation" in his language) in the received light by merely amplifying the detected beam by the inverse of the fractional decrease in power, which, in this typical example, is an amplification factor of 10,000 (or, 30 dB). This situation is highly inefficient and undesirable from a practical perspective due to at least the fact that amplifiers add noise to a signal. Willebrand's spatial resolution is, in reality, designed to process a diffraction-limited detected beam, which is that of a single spot. There are no provisions implied or anticipated by Willebrand to deal with more than a single, pristine spot (for example, even two spots, not to mention 10,000 spots). Willebrand does not even mention the existence of such

higher-order wavefront distortions.

Since a focus error involves a radially varying refractive index pattern, Willebrand's system can not even provide compensation for such low-order errors, much less higher-order (more spatially complex) refractive index spatial profiles, as induced by atmospheric turbulence, which, incidentally, can change on the order of 1,000 times per second. Willebrand does not show nor anticipate or teach techniques to deal with such dynamic wavefront errors.

Willebrand teaches nothing about "correcting propagation distortions of the first and second optical beams" as specifically claimed in claim 11. As such, claim 11 is not anticipated by Willebrand.

The Rejection of Claim 16 based on Willebrand

The Examiner rejects claim 16 as allegedly being fully anticipated by Willebrand. This grounds for rejection is respectfully traversed.

In rejecting claim 16 the Examiner asserts that Willebrand has first and second adaptive optical modules, the Examiner referring to focusing elements 44 and 32 in an adjustment mechanism 56 shown in Fig. 4 of Willebrand. The Examiner asserts that those elements are "for correcting for propagation distortion occurring between the first station and the interconnect."

With all due respect to the Examiner, just where is that taught by Willebrand? As indicated above, it is believed that Willebrand is silent on the issue of propagation distortion and therefore his focusing elements 44 and 32 as well as the adjustment mechanism 56 are not "adaptive optical modules" such as the term is used in the art nor are they for "correcting for propagating distortion" as specifically claimed by claim 16.

The field of **adaptive optics** has been in the open literature for over 50 years, and, the system of Willebrand does not even vaguely describe a general adaptive optical system. That is, an optical system, consisting of only fixed focal length lenses and line-of-sight positioning mechanisms, does not have the ability to address and compensate for typical atmospheric propagation distortions. One of the most basic propagation errors is a "focus" error, and, using the lens-based

system in Willebrand is not sufficient to compensate for that class of wavefront error. That is, one requires a wavefront detection system such as a transducer with feedback to control a variable focal length lens to correct for such an error, which Willebrand does not describe or anticipate (and, as stated above, higher-order wavefront distortions, much less, the method to compensate for such distortions, are also not anticipated by Willebrand). Since the only "adjustment mechanism" used by Willebrand controls the receiver position, the use of the term "adaptive optics" to describe Willebrand is totally inconsistent with how that term is properly used by a person skilled in the art. Moreover, this basic lens-positioner-lens system does not correct for propagation distortion, as described in detail above, and would not be referred to as an adaptive optical system by one skilled in the art.

The U.S. Government, through the National Science Foundation, has established a Center for Adaptive Optics. See the website at cfao.ucolick.org. As described at that site, adaptive optics "provides a means for compensating for these effects, leading to appreciably sharper images sometimes approaching the theoretical diffraction limit. With sharper images comes an initial gain in contrast -- for astronomy, where light levels are often very low, this means fainter objects can be detected and studied."

This site explains how adaptive optic systems work and states that "all AO systems work by determining the shape of the distorted wavefront, using an "adaptive" optical element -- using a deformable mirror -- to restore the uniform wavefront by applying an opposite canceling distortion." Where is there any suggestion in Willebrand that his lenses are deformable in such a way that they are for "correcting a propagation distortion occurring" in his optical paths? His optics are not adaptive optics and thus do not have either a "first adaptive optical module" much less a "second adaptive optical module" as claimed by claim 16.

The U.S. government knows how important adaptive optics are to the point that a center is set up at a university to deal with adaptive optics. The USPTO, through the Examiner, should not be taking a position that adaptive optics are something else again.

Claim 16 is not anticipated by Willebrand.

The Rejection of Claim 45 based on Willebrand

Claim 45 recites, among other things "providing an adaptive optical module in the propagation path of the first beam and in the propagation path of the second beam". Since Willebrand does not use adaptive optics, he does not meet the limitation of "providing adaptive optical module" much less disposing one as indicated in claim 45.

The Examiner refers to a "first adaptive optical module" parenthetically as the transmitting beam focusing element, receiver positioning mechanism and receiver focusing element. And asserts that this adaptive optical module corrects "for propagation distortions." With all due respect, both of these statements are not only incorrect in a general sense, they also do not imply or anticipate the claimed invention. The term, "adaptive optical module" does not appear anywhere in Willebrand. Therefore, the Examiner is impermissibly relying on hindsight to even refer to such a term, much less associate this term with Willebrand's optical components mentioned above. See MPEP § 2142 which discusses the fact that Examiner's often have a tendency to resort to hindsight based upon applicant's disclosure and that such practice is to be avoided.

The Rejection of Claim 68 based on Willebrand

Willebrand does not disclose "a pair of AO modules" as recited therein, and therefore Willebrand does not anticipate claim 68.

The Obviousness Rejections

The Examiner rejects claims 12-15, 17-23, 32-44, 46, 48, 51-57 and 63-67 under the 35 U.S.C. 103 as being unpatentable over Willebrand in view of Friedman (U.S. Patent No. 6,217,100). These rejections are respectfully traversed.

Willebrand teaches an optical-fiber-based communications system with free-space communications capability; no mention is made of any provision for wavefront control or correction. Willebrand teaches the measurement of the power of a beam and increasing the transmitter power as a means to "correct" for atmospheric losses or moving the placement of the

receiver to account for optical bending in the atmosphere.

Friedman teaches a system which is really a fancy camera that requires one to look upwards, since, the "guide star" is specifically located in a thin upper layer of the atmosphere, about 92 km above the surface of the earth. Thus, the Friedman invention involves a one-way optical imaging system, which requires a "guide-star" reference for wavefront control. There is no provision, or, even an implication, for a two-way relay of information, since obviously a camera is not intended to send out information. The presence of the guide star is critical in obtaining information for wavefront control of the imaging camera. Therefore, this camera only works when it is aimed upwards (guide stars only exist in the upper atmosphere; and, the camera does not function without a guide star).

Friedman is quite consistent in many ways with the teachings of the aforementioned web site for Adaptive Optics in that both are concerned with information travelling one way from a source to a camera or observer. The information which travels has many, many pixels associated with it.

As opposed to Willebrand, there is not, in general, an optical amplifier in the Friedman system, and, consequently, no correction for any uniform atmospheric losses via amplifying what is received by the camera. Moreover, the power measurement by Willebrand does not provide sufficient information for wavefront control, and, cannot replace the function of a guide star. A camera is a one-way imaging device, that is, a passive object in space is imaged into a receiver in the presence of an independent reference source (the guide star) in order to enable restoration of the received image to become recognizable.

Trying to combine the Willebrand and Friedman patents mentioned by the Examiner is tantamount to somehow incorporating a fancy camera (that only works when it is looking upwards) and a 2-way laser link (typically, directed in a horizontal or tilted path...but, almost never directly upwards), to somehow enable the composite system to simultaneously compensate for wavefront distortions and be free of the constraint to always look upwards.

Why would a person skilled in the optical communications technologies ever consider an upwards-only-looking camera to enable a terrestrial communication system to enhance its performance? As an example, what would motivate the optical communications engineer to place an upwards-looking camera on a hilltop so that an optical transmitter, aimed from the

valley below to the hilltop, could, somehow be received by the upwards-looking camera, and, then, somehow, using the image from the upward-constrained camera, send the signal downwards from the hilltop to an optical receiver in a different valley on the other side of the hilltop in a distortion free manner?

More importantly, why would a person skilled in the optical communications art look to the camera art such as that taught by Friedman? Note that the communications system patent of Willebrand has additional constraints, since it employs EDFAs as fundamental control components in the system: (1) The EDFAs are typically "single-mode" devices. That is, they only process a single pixel in a spatial sense (the communications engineer would not be motivated or ever inclined to consider more than a single spatial mode or pixel, since, there is no image information being processed in a conventional communication system such as that taught by Willebrand where only temporally encoded (modulated) messages are transmitted; and (2) the EDFA amplifies light only over a relatively small spectral region (by virtue of the fundamental quantum mechanical properties of the optical transitions in the amplifying medium), which is precisely what a communications engineer desires in the first place ... namely, why amplify light outside the narrow spectral region of the channel-link frequency? Additional bandpass would only add noise to a communications channel, since, other than about 10 Gb/s of useful bandwidth, photons outside this relatively narrow bandpass (by the imaging community) would contain no signal information, and, thus, add noise to the system, leading to a decrease in signal-to-noise (which is very undesirable to those skilled in the communications arts). By complete contrast, the optical engineer that requires an imaging camera desires to consider a relatively huge optical spectral bandwidth, typically, on the order of 1000s of angstroms or more, so that a "white-light" (e.g., sun-illuminated) image can be viewed. The EDFA fiber, given its fundamental narrow passband (1/10,000 of an angstrom or less), would not be considered for an imaging camera, given its need to process many colors of light, especially for typical applications attempting to observe objects, which are illuminated at extremely low light levels (which would be totally incompatible with a single-mode, narrowband optical fiber).

The use of such a fiber-based amplifier system in a camera is equivalent to placing an extremely narrowband filter in front of the camera; so narrow, in fact, to be essentially useless for attempting to observe a "white-light" object. Granted, filters are employed in photography, but, these filters typically allow transmission over a moderate set of wavelengths (about 100 angstroms,) versus the extremely narrow bandpass of the EDFA, which is typically 100,000

times more restrictive, and, therefore, totally impractical in an imaging system. Finally, the EDFA fiber is typically a single-mode device (i.e., it processes a single spatial pixel, in an imaging sense). The camera, by complete contrast, requires 1000 x 1000 (a million) pixels to provide a reasonably high-resolution image.

It is submitted, with all due respect, that the Examiner tries to mix these two technologies impermissibly based on a hindsight reconstruction of an invention using applicant's claims as a guide map to the prior art as opposed to a fair assessment of what the prior art is teaching. The combination suggested by the Examiner is not something which a person skilled in the art would be led to do.

The Examiner uses the term "planarizing" to describe the operation of Willebrand's invention (See page 4 of the Official Action). Where in Willebrand is the term "planarized" used? In reality, it is believed that Willebrand has no device in his system to render a distorted input beam as a planarized output beam. Also, by merely using lenses and positioning devices, the beam is, by definition, assumed to be always planarized (since he basically ignores the twinkling stars issue), as these components would only work effectively in the case of a planar wavefront.

The Examiner and Willebrand basically make the same mistake. The Examiner and Willebrand both assume that Willebrand's system is diffraction limited. The Examiner uses the term "diffraction-limited" (See the Official Action, page 5, line 19) to describe how the "first optical beam arrives at the second station" in Willebrand. The Examiner is confused here, perhaps, by Willebrand's incorrect statements or, perhaps, by using terms incorrectly to make his arguments. See the aforementioned US government sponsored website for a definition of "diffraction-limited." If, indeed, the beam arrives as a diffraction-limited beam at the second station (upon propagation through the atmosphere) in Willebrand, then, by definition, the wavefronts of the received beam are planar (i.e., a diffraction-limited beam is defined as a theoretically pristine, or perfect beam in terms of its wavefront). As such, no "adaptive optical module" would be useful, since, by definition, an "adaptive optical module" receives a distorted beam (which cannot be diffraction limited by definition), and, upon processing the beam, the adaptive optical module removes these wavefront distortions, resulting in a diffraction-limited, or planar, output beam. (Put another way, if a person already has 20/20 eyesight, it is not necessary to wear corrective lenses.) Hence, by the Examiner's own reasoning, if one were to place Willebrand and Friedman on the same table, one would NOT be motivated to combine the two, since Willebrand's system

already **assumes** that all beams are planar and diffraction-limited.

The Examiner also uses the term "adaptive optical module" as being a component in Willebrand (Office action, page 4). Where in Willebrand does this term appear? And, even if it were to appear in Willebrand, this term would then be incorrectly used, since adaptive optical systems process distorted wavefronts, rather than merely redirecting or focusing a planar wave. Just because Willebrand uses terms incorrectly (as noted above), does not mean or imply that his system teaches one how to realize these complex operations.

Hence, even if the two patents, Willebrand & Friedman, happened to be placed on the same table, it would not be obvious or even reasonable to somehow combine them. Trying to combine them is contrary to the teaching of the prior art. This would be equivalent to placing a vial containing a mixture of liquid crystals next to a CRT picture tube (as recently as 20 years ago), and, waiting, respectively, for the chemist and the electronics engineer to immediately invent the liquid crystal display for television viewing. After all, the fields of liquid crystal and cathode ray tube technologies have been around for over 50 years. Similarly, the fields of (i) adaptive optics for imaging and (ii) free-space optical communications have been well-known for over 50 years, and, it is believed that they have never been combined, as taught in the present application, by persons skilled in these arts. That is hardly surprising given the differences noted above. Optical communication systems tend to be single pixel (single mode) systems - information is applied temporally using various modulation schemes and two way communication is the norm. Cameras and astronomy (recall the aforementioned web site) embrace one way "communication" with information applied spatially with as many pixels (multimode) as possible in order to form pictures and views of the universe. The data is not modulated temporally, rather it arrives with spatial information "encoded" by distant objects, stars, and galaxies or the like. So it is submitted that it is not surprising that adaptive optics have not heretofore made their way into optical communication systems and neither Willebrand nor Friedman suggest otherwise.

Reconsideration of this application is respectfully requested.

Respectfully submitted,

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as first-class mail in an envelope addressed to Commissioner of Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on

February 1, 2006
(Date of Deposit)

Shannon Tinsley

STinsley
(Signature)

2/1/06
(Date)

Richard P. Berg
Attorney for Applicant
Reg. No. 28,145
LADAS & PARRY
5670 Wilshire Boulevard, Suite 2100
Los Angeles, California 90036
(323) 934-2300